World Energy Consumption

The IEO2001 projections indicate continued growth in world energy use, including large increases for the developing economies of Asia and South America. Energy resources are thought to be adequate to support the growth expected through 2020.

The *International Energy Outlook 2001* (*IEO2001*) presents the Energy Information Administration (EIA) outlook for world energy markets to 2020. Current trends in world energy markets are discussed in this chapter, followed by a presentation of the *IEO2001* projections for energy consumption by primary energy source and for carbon emissions by fossil fuel. Uncertainty in the forecast is highlighted by an examination of alternative assumptions about economic growth and their impacts on the *IEO2001* projections and how future energy intensity trends could influence the reference case projections. The chapter ends with a comparison of the *IEO2001* projections with forecasts available from other organizations.

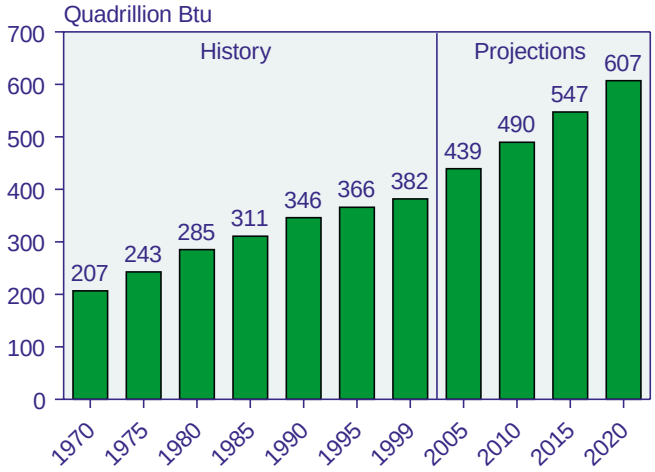
Current Trends in World Energy Demand

In the *International Energy Outlook 2001* (*IEO2001*) reference case, world energy consumption is projected to rise by 59 percent between 1999 and 2020, reaching 607 quadrillion British thermal units (Btu) at the end of the forecast (Figure 13). This projection is similar to last year's forecast, despite the high world oil price environment that largely defined 2000, stronger than anticipated economic recovery in southeast Asia, and positive economic growth in the former Soviet Union that has been sustained for 2 years—the first time this has occurred since the dissolution of the Soviet Union.

As in past *IEO*s, the highest growth in energy consumption over the projection period is expected in the developing countries, particularly those of developing Asia and Central and South America (Figure 14). Much of the projected increase in energy use in the developing world is attributed to expectations for strong economic growth accompanied by higher standards of living and new demand for personal motorization, home appliances, cooking, space heating, and cooling services.

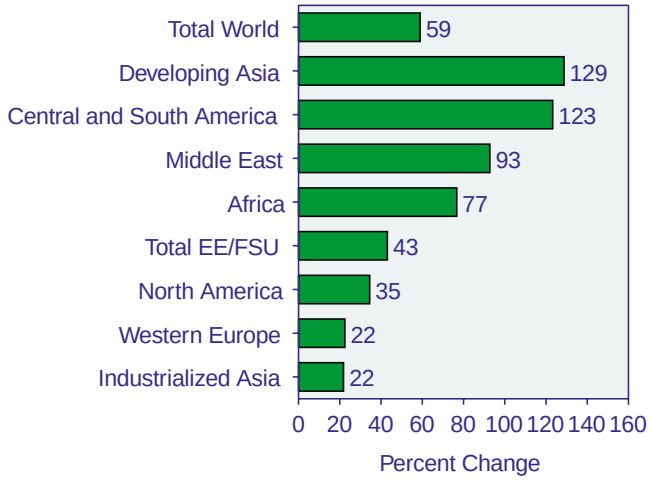
The energy markets of the past year have been strongly influenced by trends in world oil prices, which have been extremely volatile for the past 3 years (Figure 15). Consumers enjoyed oil prices that slipped to $10 per barrel in 1998, with oversupply caused by lowered worldwide demand resulting from the Asian economic recession that began in the spring of 1997, increases in oil exports from Iraq, and warmer than expected winters in North America and Western Europe. Since then, world oil prices have more than tripled, reaching a daily peak of $37 per barrel, rates not seen since the Persian Gulf

Figure 13. World Energy Consumption, 1970-2020



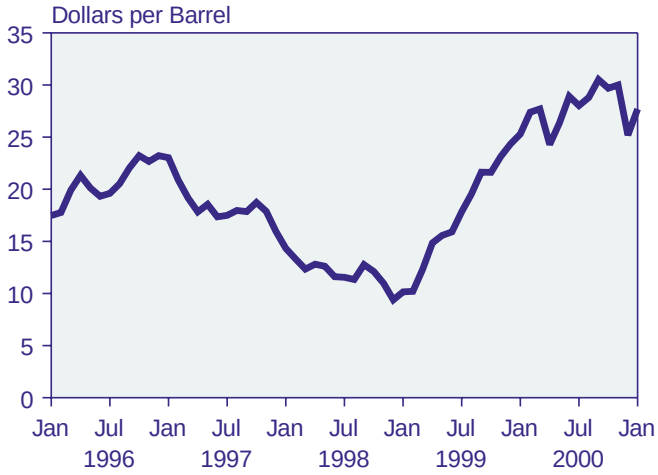
Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Figure 14. Projected Change in Energy Demand by Region, 1999-2020



Sources: **1999:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **2020:** EIA, World Energy Projection System (2001).

Figure 15. Refiner Acquisition Cost of Imported Crude Oil, 1996-2000



Source: Energy Information Administration, "Crude Oil Price Summary," MER Spreadsheet, Table 9.1, web site www.eia.doe.gov/emeu/mer/prices (October 2000).

War of 1990-1991. The high prices can be traced to a tightening of production by OPEC member countries and several non-OPEC countries (Russia, Mexico, Oman, and Norway) and to the unexpectedly strong demand for oil in the recovering economies of southeast Asia. Unrest in the Middle East has exacerbated the price volatility.

By mid-2000, after several months of oil prices in excess of $30 per barrel, OPEC member Saudi Arabia announced a desire to bring oil prices to an "optimal range" of $22 to $28 per barrel—a price level that would give oil producers reasonable compensation without adversely affecting the economic growth of oil-consuming countries worldwide. Because prices remained above this range for much of the first half of 2000, OPEC members at their June 2000 meeting pledged production increases of 708 thousand barrels per day beginning in July 2000. EIA estimated that only Saudi Arabia, Kuwait, and, to a lesser degree, the United Arab Emirates would have the productive capacity to provide the additional supplies [***1***].

The increased supply pledged by OPEC had little or no impact on world oil prices, and in July, Saudi Arabia announced that to bring the OPEC basket price down to $25 per barrel, the country would increase crude oil supplies by another 500 thousand barrels per day if oil prices remained high [***2***]. On September 10, 2000, OPEC met again and announced further production quota increases of 800 thousand barrels per day beginning in October. However, analysts voiced concerns about the stability of Iraqi supply, given a sharp drop in production in June 2000 [***3***]. In mid-September 2000, Iraqi President Saddam Hussein asked other OPEC member countries not to increase production and also accused Kuwait of producing oil from Iraqi oil fields.

Concerns in the United States about a potential shortage of home heating fuel oil for the Northeast—given the very low stock levels of August 2000—led to the September 22 decision by the Clinton Administration to allow industry access to as much as 30 million barrels of crude oil from the Nation's Strategic Petroleum Reserve (SPR). Oil prices fell from $33 per barrel to about $30 per barrel immediately after the announcement.

European Union (EU) member countries Spain and France signaled a desire to follow the U.S. lead and release their government-owned oil reserves (in the EU many member countries are required to maintain 90 days of oil supply reserves) to bring down prices in the short run, but the International Energy Agency (IEA), United Kingdom, and Germany stated their opposition to such a move, believing that government stocks should be used only for emergency purposes and not to manipulate prices [***4***]. A release of Europe's emergency stocks cannot occur without IEA approval.

Many European countries witnessed growing consumer anger over high motor fuel prices in the third quarter of 2000. European consumers are not generally sensitive to changes in motor vehicle fuel prices—particularly relative to U.S. consumers—because motor fuels are often subject to much higher taxation rates than in the United States [***5***]. Taxes make up more than 50 percent of the retail price for motor gasoline in most European countries. With crude oil prices hovering at $37 per barrel in September, truckers and farmers in France staged a strike demanding that the government reduce taxes on diesel fuel, arguing that high prices were making it impossible for their businesses to be profitable. After 3 weeks, the French government agreed to reduce fuel prices for farmers and truckers by 15 percent. Strikes quickly spread to other European countries, including Belgium, Germany, Italy, the Netherlands, and the United Kingdom, with additional strikes launched or threatened in Norway, Spain, Sweden, Greece, and Ireland.

The strike in the United Kingdom was particularly dramatic. Truckers and taxi cab drivers blockaded oil refineries throughout the country. More than 90 percent of the country's gasoline stations were reporting shortages or ran out of fuel altogether as panic buying occurred and refinery tanker drivers were unable or unwilling to risk attempts to deliver new supply in the atmosphere of the week-long strike. The protesters were demanding tax reductions in a country that currently has the highest tax burden on motor fuels in Western Europe. About 75 percent of the price of motor gasoline in the United Kingdom is federal tax. While the Blair Administration refused to reduce the taxes, at the end of the first week of the strike government officials conceded a willingness to look at reducing—or at least not increasing—motor fuel taxes in their next budget talks.

Fuel price protests eventually spread to several Eastern European countries, including Poland, Slovenia, and the Czech Republic and even beyond the European continent. In late September, in the wake of a political bribery scandal that forced Peru's President Fujimori to call for new presidential elections, political tensions and high fuel prices prompted a strike by truckers and bus drivers similar to those staged in Europe. The strikers disrupted port activity, which all but stopped Peruvian exports. In one week, exports fell by an estimated 95 percent according to the Peruvian National Ports Office [***6***]. Protesters demanded that the government reduce fuel taxes by 42 percent and lower highway tolls, even though world oil prices fell by nearly 20 percent during the 10-day strike.

In Asia, both Indonesia and Malaysia—both net oil exporters—have raised motor gasoline prices because of the high oil price environment. Thousands of Indonesians turned out to protest the one-day-old price hike in October 2000, and increasing social unrest threatens to unhinge the country's efforts to recover from the political and economic crisis of 1997-1999 [***7***]. Malaysia did raise motor gasoline prices in 1999, by between 20 and 40 cents per gallon, but this represented the first increase in gasoline prices since 1983, and Malaysian consumers will still only pay between $1.30 and $1.50 cents per gallon for their fuel [***8***]. Car sales in Malaysia have been increasing at a rapid pace (by 23 percent between 1999 and 2000 alone), and it is difficult to imagine that the demand for transportation fuels will decline as a result of the increase in gasoline prices.

The recent developments outlined above underscore the importance of world oil markets in today's global economy. It was largely the economic crisis in Asia that led to surplus oil supply in 1998, and the region's stronger than anticipated economic growth and accompanying growth in oil demand were in part responsible for the oil supply deficits in 2000. The countries of southeast Asia have recovered much more quickly from their 1997-1999 recession than most analysts predicted. EIA's *Short-Term Energy Outlook* estimated that oil demand in developing Asia (excluding China, but including India and South Korea) grew by about 400 thousand barrels per day between 1999 and 2000, after falling by 300 thousand barrels per day between 1997 and 1998 and increasing by only 100 thousand barrels per day between 1998 and 1999 [***9***]. In China, oil demand has grown steadily by 200 thousand barrels per day each year between 1997 and 2000.

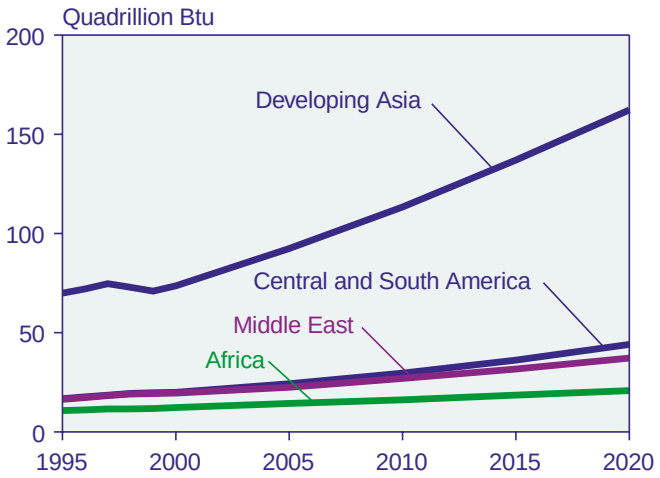
In the *IEO2001* reference case projections, developing Asia and Central and South America are expected to have the most rapid growth rates in energy demand over the next two decades (Figure 16). In both regions, total energy demand is expected to grow by about 4 percent per year between 1999 and 2020. All the southeast Asian countries that suffered from the "Asian flu" of 1997-1999 had positive economic growth rates in 2000—even Indonesia, where political and social unrest threatened economic recovery in 1999. High oil prices went a long way toward improving the Indonesian economy in 2000 and were in large part responsible for the country's record high $2.9 billion trade surplus in July 2000 [***10***].

Brazil, with Central and South America's largest economy, has recovered from the 1999 devaluation of the real, which sent the country into recession. The country's GDP grew by only 0.8 percent in 1999. The recession was not as deep or prolonged as many analysts had feared it would be, however, and the quick recovery in Brazil, the region's major consumer, has helped keep other countries in the region from faltering badly. Between June 1999 and June 2000, automobile sales in Brazil improved by 17 percent, and automobile exports improved by 53 percent [***11***].

In 2000, economic growth in Brazil, and indeed in Central and South America as a whole, was tempered by high world oil prices and low commodity prices. Almost all the countries in the region, with the exception of Argentina and Uruguay, posted positive economic growth rates for 2000, although the recovery in most cases was dampened by sustained high world oil prices. The exception is Venezuela, the region's major oil-exporting country, where economic expansion was particularly strong in 2000. Venezuela's oil exports totaled $2.2 billion dollars in May 2000, an 88-percent increase relative to May 1999 [***12***].

High world oil prices and improved domestic industrial production have helped Russia, the largest economy in

Figure 16. Energy Consumption in the Developing World by Region, 1995-2020



Sources: **1995-1999:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

the former Soviet Union, record two consecutive years of positive economic growth for the first time since the breakup of the Soviet Union in the early 1990s. As a result of the collapse of the ruble in August 1998, domestically produced goods became competitive in international markets, and when imports collapsed, Russian consumers turned to domestic sources to meet their needs.

Russia's industrial output increased by an estimated 10.3 percent between January and June 2000, higher than in 1999 [***13***]. The production increases, supplemented by the revenues obtained in the high oil price environment of the previous year, allowed Russia's economy to grow by 3.2 percent in 1999 and an estimated 5.0 percent in 2000.

Until 2000, the region's second largest economy, Ukraine, had not recorded a year of positive economic growth in the post-Soviet era. However, 1999 produced the smallest contraction experienced by the country since its independence in 1991, and in 2000 its GDP grew by an estimated 3 percent [***14***]. Most of the growth is attributed to exports, industrial output, and improved domestic demand [***15***]. As in Russia, the weakness of the Ukrainian currency, the hryvnia, has benefited industrial production by increasing the competitiveness of Ukrainian goods in international markets. Exports were up by 24 percent in the first half of 2000.

The improvement in economic circumstances in the former Soviet Union is expected to result in energy demand growth for the region of 1.7 percent per year between 1999 and 2020, reaching 56 quadrillion Btu at the end of the forecast (but still 9 percent lower than the region's 1990 level of consumption). Between 1990 and 1994, energy use in the FSU fell by an average of 4 quadrillion Btu in each year (an average drop of between 6 and 11 percent per year); however, the rate of decline has for the most part leveled out in recent years. In 1999 the region's total energy use increased by 0.5 quadrillion Btu, perhaps signaling the end of a decade-long decline. The *IEO2001* reference case projects that energy use in the FSU will grow by 42 percent between 1999 and 2020, as compared with the 36-percent loss in demand between 1990 and 1999.

In contrast to the FSU, Eastern Europe began to enjoy measurable economic recovery soon after the fall of the Soviet Union. The region as a whole began to experience sustained positive economic growth after 1993, although the growth was slower between 1996 and 1999. Several developments led to the 1996-1999 economic slowdown in Eastern Europe. First, there were substantial downturns in two of the region's key economies, the Czech Republic and Romania. Moreover, Western European demand for East European goods was weaker because of economic recession in several key countries. Finally, the Eastern European economies felt the impact of the Russian and Ukrainian economic crises after the devaluation of the ruble in 1998, as well as the effects of government fiscal austerity programs that were put into place to deal with trade and payment imbalances [***16***].

The economic downturn in the Czech Republic was the result of a growing imbalance between trade and payments that required tightened fiscal policies [***17***]. In Romania, limited economic reforms and tight monetary policies aimed at restoring macroeconomic stability caused a series of sharp economic downturns in the 1997-1999 period [***18***]. All the countries in the region showed positive GDP growth in 2000. By 2020, energy consumption in Eastern Europe is projected to be almost 8 percent above the region's 1990 level.

North America's GDP growth remained robust in 2000, at an estimated 5.2 percent for the United States, 4.7 percent for Canada, and 5.6 percent for Mexico. In the short run, high world oil prices and high natural gas prices are expected to force a slowdown of the U.S. economy and increase inflation rates. Further, because of the interdependence of the economies that make up the North American Free Trade Agreement (NAFTA), the slowdown of the U.S. economy is virtually guaranteed to slow the growth of the economies of the two other member nations.

In the United States, oil consumption in 2000 was only 0.2 percent higher than in 1999. EIA's *Short-Term Energy Outlook* expects demand growth to average 1.9 percent in 2001, with the assumption that world oil prices will remain near $30 per barrel through 2001 and then drift downward, falling by perhaps a dollar per barrel between 2001 and 2002 [***19***]. In the long term, oil demand is projected to increase by 1.5 percent per year in North America as a whole, with particularly strong growth of 3.7 percent per year in Mexico.

In 2000, the European Union's currency, the euro, faced a difficult year as its value plunged to a low of $0.84 from highs of about $1.20 when it was first released in January 1999 [***20***]. In late September 2000, the International Monetary Fund convinced several international banks, including the European Central Bank, the Bank of Japan, and the U.S. Federal Reserve, to bolster euro exchange rates and attempt to control inflation through the purchase of as much as £5.5 billion worth of euros (about 7.9 billion U.S. dollars). The euro is scheduled to become the single currency of the 11 members of the European Union (Austria, Belgium, Finland, France, Germany, Ireland, Italy, Luxemburg, the Netherlands, Portugal, and Spain) by January 1, 2002, when actual euro notes and coins are to be issued [***21***]. The euro has suffered several disappointments, however, including Denmark's rejection of the referendum on adopting the euro in late September 2000 given its weak performance in 2000.

Sweden and the United Kingdom are slated to hold referenda on euro membership, but neither country has yet set a date for the voting.

The weakness of the euro bolstered exports from EU member countries by making European goods cheaper in outside markets and reducing the competitiveness of goods from the United States and Japan in European markets. That said, the performance of the euro relative to the yen and the dollar has contributed, along with high world oil prices, to inflation levels exceeding the European Central Bank's limit of 2.4 percent. In the short term, high energy prices and a weak euro may dampen energy demand growth in Europe (particularly given the region's high tax burden on energy sources). In the long run, however, energy consumption in Western Europe is expected to increase by 1.0 percent per year in *IEO2001*, largely unchanged from the projection in last year's reference case forecast.

Japan's economy showed modest improvement in 2000. After a 2.5-percent decline in GDP in 1998 and virtually no economic growth in 1999, the country's GDP grew by an estimated 1.9 percent in 2000 [***22***]. Japan's government ended its zero-interest rate policy in August 2000, and domestic banks raised their prime lending rates by one-eighth of a percentage point, but the strength of the yen did not seem to be affected. There is some fear, however, that high world oil prices may slow the recovering economy. Increases in consumer spending cannot be described as "sustained," and the Japanese government is considering a 10 trillion yen stimulus package to boost economic growth. The government implemented a 22 trillion yen economic stimulus package in November 1998 [***23***].

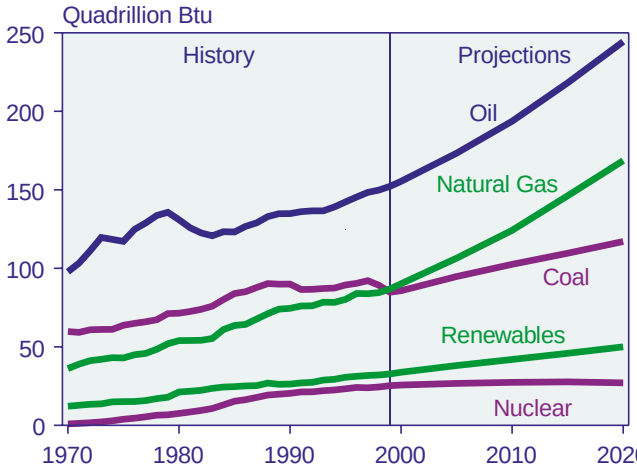
Outlook for Primary Energy Consumption

The *IEO2001* reference case projects that consumption of every primary energy source will increase over the 21-year forecast horizon, with the exception of nuclear power (Figure 17). Most of the increment in energy consumption in the reference case is in the form of fossil fuels (oil, natural gas, and coal), because *IEO2001* projects that fossil fuel prices will remain relatively low through the forecast period, and that the cost of generating energy from non-fossil energy will not be as competitive. However, should environmental programs or government policies designed to limit or reduce greenhouse gas emissions, such as the Kyoto Protocol[2] or its successor, come into play, the outlook might change, and non-fossil fuels (including nuclear power and renewable energy sources such as hydroelectricity, geothermal, biomass, solar, and wind power) might become more attractive. The *IEO2001* projections only account for government policies or programs in place as of October 1, 2000.

Oil is expected to remain the dominant energy fuel throughout the forecast period, as it has been for decades. In the industrialized world, increases in oil use are projected primarily in the transportation sector, where there are currently no available fuels to compete with oil products. The *IEO2001* reference case forecast assumes that oil use for electricity generation will decline, as other fuels (mostly natural gas) will be more favorable alternatives to oil-fired generation.

In the developing world, oil consumption is projected to increase for all end uses. In countries where noncommercial fuels have been widely used in the past (such as fuel wood for cooking and home heating), diesel generators are now sometimes being used to dissuade populations from decimating surrounding forests and vegetation. Because the natural gas infrastructure necessary to expand gas use has not been as widely established in the developing world as it has in the industrialized world, gas use is expected to grow in the

Figure 17. World Energy Consumption by Fuel Type, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

[2]The Kyoto Climate Change Protocol, devised by the United Nations Framework Convention on Climate Change, requires reductions or limits to the growth of carbon emissions within the Annex I countries (Australia, Austria, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine, the United Kingdom, and the United States) between 2008 and 2012, resulting in a 4-percent reduction in emissions relative to 1990 levels. The Protocol has not yet been ratified by any of the Annex I countries.

developing world, but not enough to accommodate all of the increase in demand for energy.

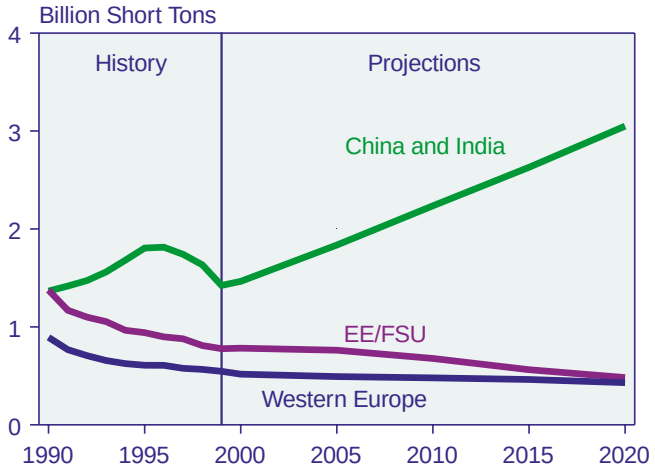
Natural gas is projected to be the fastest growing primary energy source worldwide, maintaining growth of 3.2 percent annually over the 1999-2020 period, more than twice as high as the rate for coal. Natural gas consumption is projected to rise from 84 trillion cubic feet in 1999 to 162 trillion cubic feet in 2020, primarily for electricity generation. Gas is increasingly seen as the desired alternative for electric power, given the efficiency of combined-cycle gas turbines relative to coal- or oil-fired generation, and because it burns more cleanly than either coal or oil, making it a more attractive choice for countries interested in reducing greenhouse gas emissions.

Coal use worldwide is projected to increase by 1.7 billion short tons (36 percent) between 1999 and 2020. Substantial declines in coal use are projected for Western Europe and the EE/FSU countries where natural gas is increasingly being used to replace coal, to fuel new growth in electric power generation, and for other industrial and building sector uses (Figure 18). In the developing world, however, even larger increases in coal use are expected. The largest increases are projected for China and India, where coal supplies are plentiful. Together these two countries account for more than 90 percent of the projected rise in coal use in the developing world over the forecast period.

Worldwide consumption of electricity generated from nuclear power is expected to increase from 2,396 billion kilowatthours in 1999 to 2,636 billion kilowatthours in 2015 before declining to 2,582 billion kilowatthours at the end of the forecast period. Most of the growth in nuclear capacity in the reference case is expected to occur in the developing world (particularly in developing Asia), where consumption of electricity generated from nuclear plants is projected to increase by 4.9 percent per year between 1999 and 2020. In contrast, older reactors are expected to be retired in the industrialized world and the FSU, and few new reactors are planned to replace them. Exceptions include France and Japan, where several new reactors are expected to begin operating in the next decade or so. On the other hand, if the Kyoto Protocol or a successor agreement were enacted, it is possible that the lives of non-carbon-emitting nuclear facilities could be extended and the decline of nuclear generation forestalled if industrialized countries attempt to reduce their greenhouse gas emissions.

Consumption of electricity from hydropower and other renewable energy sources is projected to grow by 2.0 percent annually in the *IEO2001* forecast. With fossil fuel prices projected to remain relatively low in the reference case, renewable energy sources are not expected to be widely competitive, and the renewable share of total energy use is expected to decline from 9 percent in 1999 to 8 percent in 2020. Like nuclear power, renewable energy could get a boost if the Annex I countries (those countries that have the responsibility to reduce or limit greenhouse gas emissions under the Kyoto Protocol) enacted policies requiring reductions in greenhouse gas emissions. Such policies would encourage nations to use non-carbon-emitting energy sources to reduce their reliance on fossil fuels and, consequently, reduce their emissions.

Figure 18. World Coal Consumption by Region, 1990-2020

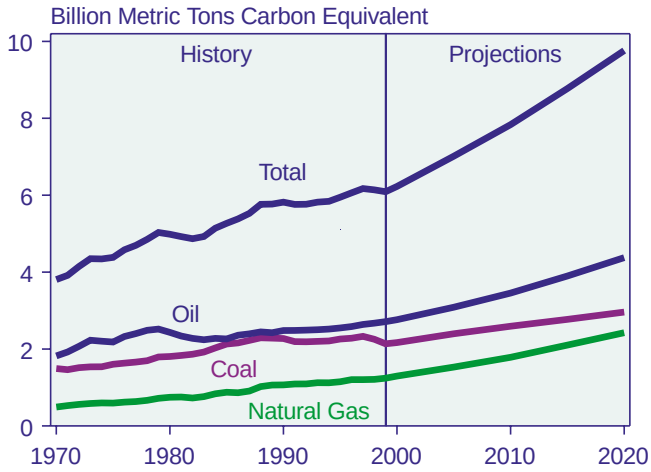


Sources: **History:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Outlook for Carbon Dioxide Emissions

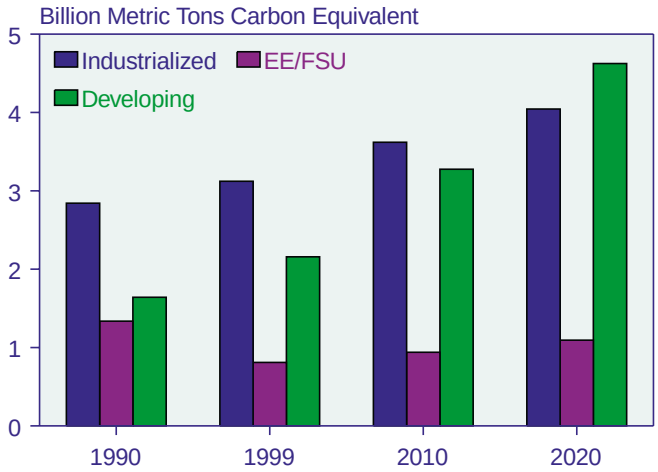
If fossil fuel consumption grows to the levels projected in the *IEO2001* reference case, carbon dioxide emissions are expected to rise to 7.8 billion metric tons carbon equivalent in 2010 and to 9.8 billion metric tons by 2020 (Figure 19). Much of the increase is expected in the developing countries, where emerging economies are expected to produce the largest increases in energy consumption, and carbon dioxide emissions are projected to grow by an average of 3.7 percent per year between 1999 and 2020. Developing countries alone account for 81 percent of the projected increment in world carbon emissions between 1990 and 2010 and 76 percent between 1990 and 2020 (Figure 20). Continued heavy reliance on coal and other fossil fuels projected for the developing countries ensures that even if the Annex I countries were to adopt the terms of the Kyoto Protocol, worldwide emissions would still grow substantially over the forecast horizon.

Figure 19. World Carbon Dioxide Emissions by Fuel Type, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Figure 20. World Carbon Dioxide Emissions by Region, 1990-2020



Sources: **1990 and 1999:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Oil consumption is projected to account for the largest increment in worldwide carbon dioxide emissions. In 2020, emissions related to oil use are projected to be 1.9 billion metric tons carbon equivalent higher than the 1990 level. Emissions from natural gas use are expected to be 1.4 billion metric tons above 1990 levels in 2020 and emissions from coal use 0.7 billion metric tons above 1990 levels. Although natural gas use is expected to increase at a faster rate than oil use, it is a less carbon-intensive fuel.

The Kyoto Protocol, if ratified and implemented, could influence future patterns of energy consumption, as well as carbon dioxide emissions. As of February 2001, 83 countries and the European Community had signed the treaty. It was ratified by 32 signatories but not by any of the Annex I countries that would be required to limit or reduce their greenhouse gas emissions relative to 1990 levels under the terms of the Protocol [***24***]. The Protocol will not enter into force until the "ninetieth day after the date on which not less than 55 Parties to the Convention, incorporating Annex I Parties which accounted in total for at least 55 percent of the total carbon dioxide emissions for 1990 from that group, have deposited their instruments of ratification, acceptance, approval or accession."

If the Kyoto Protocol became law and the industrialized Annex I countries tried to reduce emissions solely by cutting fossil fuel consumption, reductions in energy use between 30 and 60 quadrillion Btu would be necessary (depending on the mix of fossil fuels used to achieve the reduction because of the relative differences in carbon intensity among the fossil fuels).[3] It is more likely, however, that most countries would attempt to reduce greenhouse gas emissions through alternative strategies, such as fuel switching, conservation measures, reforestation, emissions trading, and others.

Because there were no binding agreements to reduce or limit greenhouse gas emissions at the time this report was prepared, the *IEO2001* reference case projections have not been adjusted to account for the impact of any potential policy. Carbon dioxide emissions in the industrialized Annex I countries alone are projected to grow to 3,475 million metric tons carbon equivalent in 2010 and 3,841 million metric tons in 2020, from 2,758 million metric tons in 1990 (Figure 21). About half the expected increment is attributed to natural gas consumption, because many of the industrialized Annex I countries are increasingly turning to natural gas for new electricity generation because of its relative efficiency and low carbon dioxide emissions. Total Annex I emissions are projected to grow to 4,276 million metric tons carbon equivalent in 2010 and 4,771 million metric tons in 2020 from 3,890 million metric tons in 1990.

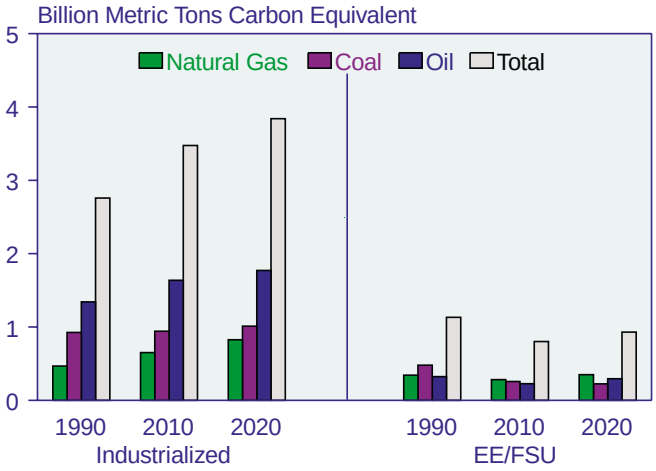
Oil accounts for more than 40 percent of the projected increase in carbon dioxide emissions in the industrial Annex I countries, which rely heavily on oil for transportation and, at present, have few economical alternatives. Only 8 percent of the projected increase in carbon

[3]This range was calculated by removing consumption of the most carbon-intensive fossil fuel possible, coal, and the least carbon-intensive fuel possible, natural gas, with the understanding that it probably would be impractical to reduce consumption of coal only, and a combination of fossil fuels would have to be reduced.

dioxide emissions for the region are attributed to coal use. Projected decreases in coal consumption in Western Europe and moderate increases in the other industrialized countries account for coal's smaller portion of rising emissions.

Carbon dioxide emissions fell by 431 million metric tons in the Annex I transitional economies of the EE/FSU between 1990 and 1999, from 1,132 million metric tons to 700 million metric tons carbon equivalent. Emissions in the Annex I EE/FSU countries are expected to rise to 802 million metric tons carbon equivalent in 2010 and to 930 million metric tons in 2020, remaining below their 1990 level even at the end of the forecast horizon.

Figure 21. Carbon Dioxide Emissions in the Annex I Countries by Fuel Type, 1990, 2010, and 2020



Sources: **1990:** Energy Information Administration (EIA), *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **2010 and 2020:** EIA, World Energy Projection System (2001).

IEO2000 projected that the Annex I EE/FSU countries would provide 318 million metric tons of potential emissions allowances for the Annex I emissions reduction effort in 2010. In *IEO2001* the projection is slightly higher, at 348 million metric tons. Without allowance trading, the industrialized Annex I countries would have to reduce their emissions by a combined 901 million metric tons (or 26 percent) relative to the reference case projection for 2010 (Table 2). Because the EE/FSU Annex I countries are projected to emit about 348 million metric tons less than their Protocol targets, however, Annex I member countries as a whole need to reduce their combined emissions by only 554 million metric tons (or 13 percent) in 2010 relative to the baseline projection.

Alternative Growth Cases

A major source of uncertainty in the *IEO2001* forecast is the expected rate of future economic growth. As a measure of economic growth *IEO2001* uses gross domestic product (GDP), which is accompanied by its own issues of uncertainty (see box on page 15). *IEO2001* includes a high economic growth case and a low economic growth

Table 2. Carbon Dioxide Emissions in the Annex I countries, 1990 and 2010, and Effects of the Kyoto Protocol in 2010
(Million Metric Tons Carbon Equivalent)

Region and Country	1990 Emissions	2010 Baseline Projection		2010 Kyoto Protocol Target	Reduction From 2010 Baseline	Percent Change	
		IEO2001 Reference Case	Percent Change from 1990			From 1990	From 2010 Baseline
Annex I Industrialized Countries							
North America	1,472	1,979	34	1,370	604	-7	-31
United States	1,345	1,809	34	1,251	558	-7	-31
Canada	126	165	31	119	46	-6	-28
Western Europe	930	1,040	12	856	184	-8	-18
Industrialized Asia	357	461	29	347	113	-3	-25
Japan	269	330	23	253	77	-6	-23
Australasia	88	130	48	94	36	7	-28
Total	**2,758**	**3,475**	**26**	**2,573**	**901**	**-7**	**-26**
Annex I Transitional Economies							
Former Soviet Union	853	593	-30	851	-258	-0	44
Eastern Europe	279	209	-25	298	-89	7	43
Total	**1,132**	**802**	**-29**	**1,149**	**-348**	**2**	**43**
Total Annex I Countries	**3,890**	**4,276**	**10**	**3,723**	**554**	**-4**	**-13**

Sources: **1990:** Energy Information Administration (EIA), *Emissions of Greenhouse Gases in the United States 1999*, DOE/EIA-0573(99) (Washington, DC, October 2000); and EIA, *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **2010:** EIA, World Energy Projection System (2001).

case in addition to the reference case. The reference case projections are based on a set of regional assumptions about economic growth paths—measured by GDP—and energy elasticity (the relationship between changes in energy consumption and changes in GDP). The two alternative growth cases are based on alternative ideas about possible economic growth paths.

For the high and low economic growth cases, different assumptions are made about the range of possible economic growth rates among the industrial, transitional EE/FSU, and developing economies. For the industrialized countries, one percentage point is added to the reference case GDP growth rates for the high economic growth case and one percentage point is subtracted from

Uncertainty in Measures of Gross Domestic Product

The GDP forecasts underlying the *IEO2001* energy forecasts are themselves subject to uncertainty from two sources. First, because the GDP forecasts are projections of trend growth, abstracting from cyclical movements and unexpected shocks to the economy, there is the possibility that the perceived trends may not actually achieve expected levels. This type of uncertainty is inherent in all forecasts, and forecasters try to minimize it by looking at past experience. Clearly, the longer the period of the forecast the greater the uncertainty, because the more likely it is that events will not go as expected.

The second source of uncertainty about GDP forecasts has to do with the variation in the methods and accuracy with which GDP is measured among countries and over time. This source of uncertainty is the result of methodological and measurement issues and would be minimized if a common methodology and data collection method were used across countries and over time to estimate GDP.

The GDP forecasts for *IEO2001* depend on the national statistical agencies' definition of what is included in the measurement of output. *IEO2001* uses real (inflation-adjusted) GDP, which ultimately relies on the statistics released by each national statistical agency. Comparing across countries, even though conceptually GDP has common meaning, it may not be measured consistently across nations. There are several examples illustrating differences in treatment both within the more industrialized nations and among the developing countries.

Over the past year, the United States has released revised historical GDP numbers, incorporating changes in estimation of inflation, reclassification of certain investment expenditures, and more complete data. As a result, the historical GDP growth rate from 1959 to 1998 has been revised upward by 0.2 percent per year. The Bureau of Economic Analysis (BEA), the statistical agency responsible for estimating U.S. GDP, uses a methodology to estimate inflation that is not commonly used in the other industrialized countries. If a common methodology were adopted, the economic growth forecasts for some countries would be different from those published in the past.

Measurement of price changes is a central source of differences in the calculation of real output growth. The United States changed to a chain-weighted approach in 1992, rather than fixed-year prices, in order to remove substitution bias and reduce the impact of changing the base year much less noticeable in understanding economic growth.[a] Most of the other industrialized nations have not calculated price changes using chain-weighted indices but continue to use fixed-year prices to calculate real output.

Some nations, such as China and other centrally planned economies, use a "comparable prices" approach that applies constant "administrative prices" to value nominal output, rather than calculating a deflator-based estimate of price change. Data from state enterprises determine the administrative prices. Typically, state enterprise price data are applied to a wide variety of similar goods without adjusting for variation in product characteristics. Relying on administrative prices to value real output leads to greater uncertainty in estimates of inflation and, consequently, real output growth.

In developing countries, some economic activities are not recorded or monetized. National statistical agencies have devised various methods to estimate their contribution to GDP. As methodologies improve and/or more complete information becomes available over time, their GDP estimates probably will be revised. At present, however, it is difficult to predict for each economy how the changes will be made—a consideration that adds to the uncertainty about their expected GDP growth.

Finally, many countries are moving toward United Nations System of National Accounts for reporting their statistics, which is a step toward reporting country growth in a consistent framework. When all countries can convert their detailed national statistics into this framework, the "measurement uncertainty" in GDP estimates will be significantly reduced.

[a]For a description of chain-weighted indexes, see J.S. Landefeld and R. Parker, "BEA's Chain Indexes, Time Series and Measures of Long-Term Economic Growth" *Survey of Current Business* (May 1997).

the reference case GDP growth rates for the low economic growth case. Outside the industrialized world and excluding China and the EE/FSU, reference case GDP growth rates are increased and decreased by 1.5 percentage points to provide the high and low economic growth case estimates.

Because China experienced particularly high, often double-digit growth in GDP throughout much of the 1990s, it has the potential for a larger downturn in economic growth. In contrast, the EE/FSU region suffered a severe economic collapse in the early part of the decade and has been trying to recover from it with mixed success. The EE/FSU nations have the potential for substantially higher economic growth if their current political and institutional problems moderate sufficiently to allow the recovery of a considerable industrial base. As a result of these uncertainties, 3.0 percentage points are subtracted from the reference case GDP assumptions for China to form the low economic growth case, and 1.5 percentage points are added to the reference case to form the high economic growth case. For the EE/FSU region, 1.5 percentage points are subtracted from the reference case assumptions to derive the low economic growth case, and 3.0 percentage points are added for the high economic growth case.

The *IEO2001* reference case shows total world energy consumption reaching 607 quadrillion Btu in 2020, with the industrialized world projected to consume 270 quadrillion Btu, the transitional EE/FSU countries 72 quadrillion Btu, and the developing world 264 quadrillion Btu (Figure 22). In the high economic growth case, total world energy use in 2020 is projected to be 713 quadrillion Btu, 106 quadrillion Btu higher than in the reference case. Under the assumptions of the low economic growth case, worldwide energy consumption in 2020 would be 94 quadrillion Btu lower than in the reference case (or 513 quadrillion Btu). Thus, there is a substantial range of 200 quadrillion Btu, or one-third of the total consumption projected for 2020 in the reference case, between the projections in the high and low economic growth cases. Corresponding to the range of the energy consumption forecasts, carbon dioxide emissions in 2020 are projected to total 8,204 million metric tons carbon equivalent in the low economic growth case (1,558 million metric tons less than the reference case projection) and 11,505 million metric tons carbon equivalent in the high economic growth case (1,743 million metric tons higher than the reference case projection).

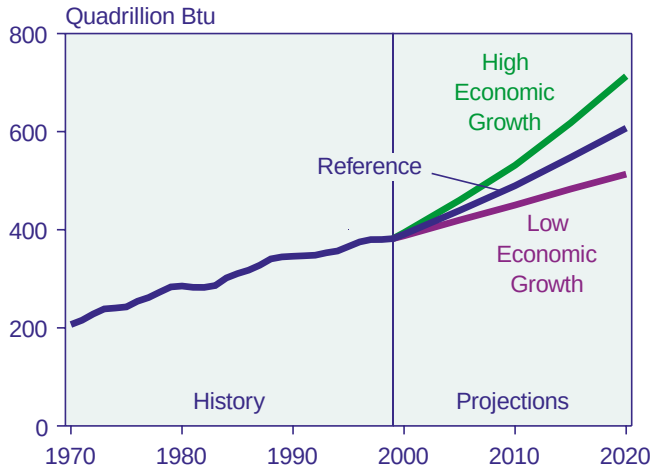
Trends in Energy Intensity

Another way of quantifying the uncertainty surrounding a long-term forecast is to consider the relationship of energy use to GDP over time. Economic growth and energy demand are linked, but the strength of that link varies among regions and their stages of economic development. In industrialized countries, history shows the link to be a relatively weak one, with energy demand lagging behind economic growth. In developing countries, demand and economic growth have been more closely correlated in the past, with energy demand growth tending to track the rate of economic expansion.

The historical behavior of energy intensity in the FSU is problematic. The EE/FSU economies have always had higher levels of energy intensity than either the industrialized or the developing countries. In the FSU, however, energy consumption grew more quickly than GDP until 1990, when the collapse of the Soviet Union created a situation in which both income and energy use were declining, but GDP fell more quickly and, as a result, energy intensity increased. Over the forecast horizon, energy intensity is expected to decline in the region as the EE/FSU nations begin to recover from the economic and social problems of the early 1990s. Still, energy intensity in the EE/FSU is expected to be almost double that in the developing world and five times that in the industrialized world in 2020 (Figure 23).

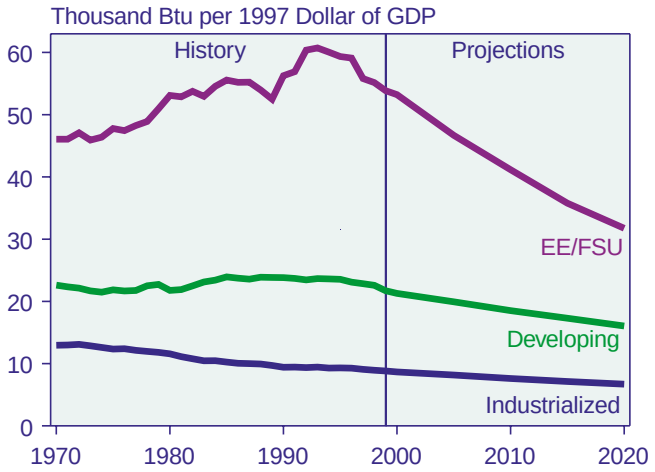
The stage of economic development and the standard of living of individuals in a given region strongly influence the link between economic growth and energy demand. Advanced economies with high living standards have relatively high energy use per capita, but they also tend to be economies where per capita energy use is stable or changes occur very slowly, and increases in energy use tend to correlate with employment and population growth.

Figure 22. Total World Energy Consumption in Three Cases, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

Figure 23. World Energy Intensity by Region, 1970-2020



Sources: **History:** Energy Information Administration (EIA), Office of Energy Markets and End Use, International Statistics Database and *International Energy Annual 1999*, DOE/EIA-0219(99) (Washington, DC, January 2001). **Projections:** EIA, World Energy Projection System (2001).

In the industrialized countries, there is a high penetration rate of modern appliances and motorized personal transportation equipment. As a result, increases in personal income tend to result in spending on goods and services that are not energy intensive. To the extent that spending is directed to energy-consuming goods, it involves more often than not purchases of new equipment to replace old capital stock. The new stock is often more efficient than the equipment it replaces, resulting in a weaker link between income and energy demand. In developing countries, standards of living, while rising, tend to be low relative to those in more advanced economies.

Changing growth patterns of energy intensity could have dramatic impacts on energy consumption in the projection period, particularly among the developing countries. For instance, if energy intensities in the developing countries are assumed to decline on average by 61 percent (which was the single greatest annual improvement observed between 1990 and 1999), energy consumption in the developing world would be just 138 quadrillion Btu in 2020, about 126 quadrillion Btu less than the reference case estimate of 264 quadrillion Btu. On the other hand, if energy intensities in the developing world are assumed to increase by 134 percent (the highest annual rate of growth observed in the 9-year period), energy consumption in the developing world would climb to 836 quadrillion Btu in 2020—more than three times the reference case projection.

Forecast Comparisons

Another way to examine the uncertainty associated with the *IEO2001* projections is to compare them with those derived by other forecasters. Four organizations provide forecasts comparable to those in *IEO2001*. The International Energy Agency (IEA) provides "business as usual" projections out to the year 2020 in its *World Energy Outlook 2000*. Standard & Poor's Platt's (S&P) also provides energy forecasts by fuel to 2020 in its *World Energy Service: World Outlook 1999*. Petroleum Economics, Ltd. (PEL) and Petroleum Industry Research Associates (PIRA) publish world energy forecasts, but only to the years 2015 and 2010, respectively. For this comparison, 1997 is used as the base year for all the forecasts.

Regional breakouts among the forecasting groups vary, complicating the comparisons. For example, *IEO2001* includes Mexico in North America, but all the other forecasts include Mexico in Latin America. As a result, for purposes of this comparison, Mexico has been removed from North America in the *IEO2001* projections and added to Central and South America to form "Latin America" country grouping that matches the other series. S&P and PIRA include only Japan in industrialized Asia, whereas industrialized Asia in the *IEO2001* forecast comprises Japan, Australia, New Zealand, and the U.S. Territories. S&P and *IEO2001* include Turkey in Middle East, but IEA includes Turkey, as well as the Czech Republic, Hungary, and Poland, in "OECD Europe" (which is designated as "Western Europe" for this comparison). PEL also places Turkey in Western Europe but includes the Czech Republic, Hungary, and Poland in Eastern Europe, as does *IEO2001*. Although most of the differences involve fairly small countries, they contribute to the variations among the forecasts.

All the forecasts provide projections out to the year 2010 (Table 3). The growth rates for energy consumption among the reference case forecasts for the 1997-2010 time period are relatively similar, ranging between 2.0 and 2.3 percent per year. All the forecasts for total energy consumption fall well within the range of variation defined by the *IEO2001* low and high economic growth cases and, in fact, are all within a range of 0.3 percentage points.

The regions for which the largest variations are seen among the forecasts are developing Asia, Latin America, and the EE/FSU. For developing Asia the projected average annual growth rates vary by 0.8 percentage points among the forecasts. *IEO2001* projects the lowest growth in energy demand in the region at 3.3 percent per year between 1997 and 2010. PIRA and PEL project the highest average growth for the 1997-2010 period, at 4.1 percent per year.

Among the nations of developing Asia, the widest variations in the energy consumption forecasts are seen for China. Both PIRA and PEL project growth rates of 4.3 percent per year, higher than projected in the *IEO2001* high economic growth case (4.0 percent per year).

Table 3. Comparison of Energy Consumption Growth Rates by Region, 1997-2010
(Average Annual Percent Growth)

Region	*IEO2001* Low Growth	*IEO2001* Reference	*IEO2001* High Growth	*IEO2000*	S&P	IEA	PIRA	PEL
Industrialized Countries	**0.9**	**1.3**	**1.6**	**1.2**	**1.4**	**1.2**	**0.9**	**1.1**
United States and Canada	1.2	1.5	1.8	1.3	1.4	1.1	1.3	1.2
Western Europe	0.7	1.1	1.5	1.0	1.5	1.3	0.9	1.1
Asia	0.3	0.8	1.3	1.1	1.0[a]	1.1	0.9[a]	0.6
EE/FSU	**0.6**	**1.1**	**2.2**	**1.3**	**1.2**	**1.4**	**1.8**	**0.9**
Developing Countries	**2.1**	**3.2**	**4.1**	**3.7**	**3.7**	**3.6**	**4.1**	**3.8**
Asia	2.0	3.3	4.1	4.1	3.7	3.9	4.1	4.1
China	1.5	3.2	4.0	4.9	3.6	3.6	4.3	4.3
Other Asia[b]	2.5	3.3	4.2	3.2	3.8	4.2	3.9	3.8
Middle East	2.1	3.0	3.9	3.0	3.4	2.7	3.2	3.4
Africa	1.7	2.6	3.4	2.5	2.6	2.9	3.3	2.7
Latin America	2.7	3.6	4.5	3.7	4.4	3.3	3.0	3.5
Total World	**1.3**	**2.0**	**2.6**	**2.1**	**2.3**	**2.1**	**2.2**	**2.1**

[a]Japan only.
[b]Other Asia includes India and South Korea.
Sources: ***IEO2001*:** Energy Information Administration (EIA), World Energy Projection System (2001). ***IEO2000*:** EIA, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000), Table A1, p. 169. **S&P:** Standard & Poor's Platt's, *World Energy Service: World Outlook 1999* (Lexington, MA, January 1999), p. 3. **IEA:** International Energy Agency, *World Energy Outlook 2000* (Paris, France, November 2000), pp. 364-418. **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2000), Tables II-4, II-6, and II-7. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, February 2000).

IEO2000 projected a reference case growth rate of 4.9 percent per year between 1997 and 2010, 1.5 percentage points higher than the *IEO2001* reference case projection of 3.2 percent per year.

The lower projection for China's energy consumption in this year's forecast reflects a precipitous drop in energy use in China between 1997 and 1999, the historical year on which the *IEO2001* forecast is based. Consumption in China fell by 13 percent from 1997 to 1999, attributable to a 24-percent (6 quadrillion Btu) reduction in coal use. As a result, while *IEO2001* projects 5.1-percent annual growth in China's energy use between 1999 and 2010, the higher historical level in 1997 results in a lower growth projection for the 1997-2010 period. The other forecasts were based either on 1997 historical data (IEA) or on the expectation that energy use in China would increase between 1997 and 1999 (PIRA, for instance, estimated an 8-percent increase in energy use over the 2-year period).

Projections for the EE/FSU differ by a range of 0.9 percentage points, varying from 0.9 percent annual growth in energy demand between 1997 and 2010 (PEL) to 1.8 percent per year (PIRA). *IEO2001* projects that energy use in the EE/FSU will increase by 1.1 percent per year over the period. Although there clearly is a great deal of uncertainty among the forecasts about how fast the economic recovery might progress over the next decade, all the energy consumption growth forecasts fall within the range defined by the *IEO2001* high and low economic growth cases.

Latin America is another region for which large difference among the forecasts are evident. The projected growth rates for energy demand from 1997 to 2010 range from 3.0 percent per year (PIRA) to 4.4 percent (S&P). The *IEO2001* reference case projects a growth rate of 3.6 percent per year for Latin America. The S&P forecast, published in January 1999, is the oldest one in this comparison, released before the economic recession that hit the region in 1999, and also the most optimistic. If S&P is not considered, the projected growth rates are separated by only 0.6 percentage points per year.

Only *IEO2001* and PEL provide forecasts for energy use in 2015, the end of the PEL forecast horizon (Table 4), and their projections for worldwide growth in energy consumption between 1997 and 2015 are similar. *IEO2001* projects average growth of 2.1 percent per year and PEL 2.0 percent per year. Regionally, however, *IEO2001* expects a much faster pace of recovery for the EE/FSU over the 1997-2015 period (1.4 percent per year) than does PEL (0.9 percent per year). *IEO2001* and PEL project similar annual growth rates for energy consumption in the countries of Eastern Europe between 1997 and 2015, with most of the variation in the EE/FSU forecasts resulting from their different expectations for the FSU.

Table 4. Comparison of Energy Consumption Growth Rates by Region, 1997-2015
(Average Annual Percent Growth)

Region	*IEO2001*			*IEO2000*	PEL
	Low Growth	Reference	High Growth		
Industrialized Countries	**0.9**	**1.2**	**1.5**	**1.1**	**0.5**
United States and Canada	1.1	1.4	1.7	1.2	1.0
Western Europe	0.6	1.0	1.4	0.9	0.9
Asia	0.4	0.9	1.5	0.9	0.4
EE/FSU	**0.9**	**1.4**	**2.5**	**1.3**	**0.9**
Former Soviet Union	1.0	1.5	2.7	1.2	0.7
Eastern Europe	0.4	1.2	1.8	1.6	1.4
Developing Countries	**2.2**	**3.4**	**4.3**	**3.4**	**3.6**
Asia	2.1	3.4	4.3	3.7	3.8
China	1.7	3.6	4.5	4.4	3.9
Other Asia[a]	1.5	3.1	3.2	3.0	3.8
Middle East	2.2	3.1	4.0	2.8	3.1
Africa	1.7	2.6	3.6	2.5	2.5
Latin America	2.6	3.2	4.7	3.6	3.5
Total World	**1.3**	**2.1**	**2.7**	**2.0**	**2.0**

[a]Other Asia includes India and South Korea.

Sources: ***IEO2001*:** Energy Information Administration (EIA), World Energy Projection System (2001). ***IEO2000*:** EIA, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000), Table A1, p. 169. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, February 2000).

IEO2001 is much more optimistic about the prospects for growth in energy use in the FSU, projecting an average increase of 1.5 percent per year, than is PEL (0.7 percent per year).

IEO2001 is also much more optimistic than is PEL about growth in the industrialized world's energy consumption (1.2 percent per year vs. 0.5 percent per year between 1997 and 2015). The *IEO2001* projections are higher than PEL's for each of the three regions of the industrialized world. Higher expectations for developing Asia in the PEL forecast, however, offset the more pessimistic forecasts for the FSU and industrialized nations.

IEO2001, IEA, and S&P provide energy consumption projections for 2020. Table 5 provides a comparison of growth rates between 1997 and 2020 by region for the three forecasts. Again, the expectations for growth in total world energy consumption are similar, ranging from 2.0 percent per year (IEA) to 2.3 percent per year (S&P), with *IEO2001* at 2.1 percent per year. There are also relatively large differences among the forecasts for the EE / FSU, with growth rate projections ranging from 1.3 percent per year (S&P) to 1.6 percent per year (IEA), with *IEO2001* at 1.4 percent per year.

There are larger differences among the three forecasts for energy demand growth in the industrialized region from 1997 to 2020. IEA is much less optimistic about growth in the United States and Canada (0.9 percent per year) than is S&P (1.1 percent per year) or *IEO2001* (1.3 percent per year). S&P is more optimistic about growth in industrial Asia (1.5 percent per year) than is *IEO2001* (1.1 percent per year) or IEA (1.0 percent per year).

For some regions of the developing world, the three forecasts are similar. The projections for Africa's energy consumption growth range between 2.6 percent per year (*IEO2001* and S&P) and 2.8 percent per year (IEA). In addition, all three expect a combined developing Asia (including China) to grow by about the same rate over the time horizon (3.4 percent per year in *IEO2001*, 3.6 percent per year in the S&P forecast, and 3.7 percent per year in the IEA forecast). Within developing Asia, however, there are strong differences among the forecasts for China. IEA and S&P project that energy use in China will grow more slowly over the 1997-2020 period than in "other Asia," but *IEO2001* expects the opposite.

A key reason for the differences among the various forecasts is that they are based on different expectations about future economic growth rates. *IEO2001*, PIRA, and PEL provide GDP growth rate projections for the 1997-2010 period (Table 6), and all have similar expectations for economic growth in the industrialized world, projecting higher growth for the United States, Canada, and Western Europe than for industrialized Asia. The *IEO2001* and PIRA forecasts for GDP growth in the United States and Canada are higher than the S&P and PEL forecasts. The GDP assumptions in *IEO2001* for the United States and Canada are a full percentage point higher than those in *IEO2000*.

Table 5. Comparison of Energy Consumption Growth Rates by Region, 1997-2020
(Average Annual Percent Growth)

Region	*IEO2001*			*IEO2000*	S&P	IEA
	Low Growth	Reference	High Growth			
Industrialized Countries	**0.8**	**1.2**	**1.5**	**1.0**	**1.2**	**0.9**
United States and Canada	1.0	1.3	1.6	1.1	1.1	0.9
Western Europe	0.6	1.0	1.3	0.9	1.2	1.0
Asia	0.6	1.1	1.6	0.9	1.5	1.0
EE/FSU	**0.9**	**1.4**	**2.5**	**1.5**	**1.3**	**1.6**
Developing Countries	**2.2**	**3.4**	**4.3**	**3.5**	**3.5**	**3.4**
Asia	2.1	3.4	4.3	3.7	3.6	3.7
China	1.8	3.7	4.6	4.3	3.3	3.4
Other Asia[a]	2.3	3.2	4.1	3.0	3.8	4.0
Middle East	2.2	3.1	4.1	2.9	3.3	2.8
Africa	1.6	2.6	3.5	2.6	2.6	2.8
Latin America	2.2	3.8	4.9	3.7	4.2	3.1
Total World	**1.3**	**2.1**	**2.8**	**2.1**	**2.3**	**2.0**

[a]Other Asia includes India and South Korea.

Sources: ***IEO2001*:** Energy Information Administration (EIA), World Energy Projection System (2001). ***IEO2000*:** EIA, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000), Table A1, p. 169. **S&P:** Standard & Poor's Platt's, *World Energy Service: World Outlook 1999* (Lexington, MA, January 1999), p. 3. **IEA:** International Energy Agency, *World Energy Outlook 2000* (Paris, France, November 2000), pp. 364-418.

Table 6. Comparison of Economic Growth Rates by Region, 1997-2010
(Average Annual Percent Growth in Gross Domestic Product)

Region	*IEO2001*			*IEO2000*	S&P	PIRA	PEL[a]
	Low Growth	Reference	High Growth				
Industrialized Countries	**2.0**	**2.7**	**3.6**	**2.2**	**2.2**	**2.8**	**—**
United States and Canada	3.3	3.5	4.4	2.5	2.6	3.4	2.8
Western Europe	1.8	2.5	3.4	2.4	2.4	2.5	2.5
Asia	-0.6	1.2	2.0	1.2	1.1	1.5	1.2
EE/FSU	**0.8**	**3.5**	**6.1**	**3.4**	**3.5**	**3.9**	**—**
Former Soviet Union	-0.2	3.1	5.5	2.9	2.2	—	1.8
Eastern Europe	2.3	4.3	7.0	4.2	4.5	—	3.4
Developing Countries	**2.4**	**4.9**	**6.1**	**4.8**	**4.5**	**4.8**	**—**
Asia	2.9	5.7	6.9	5.2	5.1	5.3	5.3
China	5.1	7.4	8.9	6.9	6.8	6.1	6.7
Other Asia[b]	1.6	4.8	5.8	4.4	4.2	4.4	—
Middle East	1.5	3.8	5.1	3.3	3.3	3.9	3.0
Africa	2.2	4.0	5.4	3.1	3.1	3.8	3.4
Latin America	2.0	4.0	5.3	4.2	4.1	3.5	3.1
Total World	**2.1**	**3.2**	**4.2**	**2.7**	**2.8**	**3.8**	**2.9**

[a]North America includes only the United States. Industrialized Asia includes only Japan.
[b]Other Asia includes India and South Korea.

Sources: ***IEO2001*:** Energy Information Administration (EIA), World Energy Projection System (2001). ***IEO2000*:** EIA, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000), Table A1, p. 169. **S&P:** Standard & Poor's Platt's, *World Energy Service: World Outlook 1999* (Lexington, MA, January 1999). **PIRA:** PIRA Energy Group, *Retainer Client Seminar* (New York, NY, October 2000), Table II-1. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, February 2000).

Expectations for economic growth in the EE/FSU region as a whole from 1997 to 2010 are also similar across the forecasts, ranging from 3.5 percent per year (S&P) to 3.9 percent per year (PIRA). PEL, which does not provide GDP growth rate assumptions for the total EE/FSU region, is less optimistic about the potential for growth both in Eastern Europe and in the FSU than is *IEO2001*, and presumably also for the entire region. Among the forecasts that provide separate projections for Eastern Europe and the FSU, there is general consensus that economic growth in the FSU will be slower than in Eastern Europe.

The *IEO2001* forecast is the most optimistic about economic growth in developing Asia between 1997 and 2010. The growth rate projections for developing Asia range from 5.1 percent per year (S&P) to 5.7 percent per year (*IEO2001*). In all the forecasts, the highest GDP growth rate is expected for China, ranging from 6.1 percent per year (PIRA) to 7.4 percent per year (*IEO2001*), and all the projections fall within the range defined by the *IEO2001* high and low economic growth cases. PEL tends to be the least optimistic in terms of economic growth for the developing regions outside of China, providing the lowest expected growth rates for the Middle East and Latin America. And, were it not for the somewhat lower estimate from S&P for Africa's average annual economic growth between 1997 and 2010, PEL's growth rate projections would also be the lowest for that region.

Three forecasts—*IEO2001*, S&P, and IEA—provide GDP growth rate projections for the 1997-2020 period (Table 7). Again, *IEO2001* is more optimistic about economic growth in the United States and Canada than are the two other forecasts. IEA projects lower economic growth rates for North America and Western Europe but higher growth for industrialized Asia, and S&P projects higher growth for Western Europe and industrialized Asia than does *IEO2001*.

IEA projects a slightly slower rate of economic recovery in the EE/FSU countries than does *IEO2001*. The difference may be explained by IEA's inclusion of the Czech Republic, Hungary, and Poland—three of Eastern Europe's strongest economies—in Western Europe (OECD Europe) rather than the EE/FSU.

Finally, the projections vary not only with respect to levels of total energy demand and economic growth but also with respect to the composition of primary energy inputs. Four of the forecasts—*IEO2001*, IEA, PIRA, and S&P—provide energy consumption projections by fuel in 2010 (Table 8). S&P does not provide a breakout of nuclear and other sources of electricity generation but instead provides a single forecast for "primary electricity."

Table 7. Comparison of Economic Growth Rates by Region, 1997-2020
(Average Annual Percent Growth in Gross Domestic Product)

Region	*IEO2001* Low Growth	*IEO2001* Reference	*IEO2001* High Growth	*IEO2000*	S&P	IEA
Industrialized Countries	**1.8**	**2.5**	**3.4**	**2.5**	**2.3**	**—**
United States and Canada	2.7	3.1	4.1	2.7	2.4	2.1
Western Europe	1.6	2.3	3.3	2.6	2.4	2.1
Asia	0.0	1.5	2.3	1.8	1.9	1.7
EE/FSU	**1.8**	**4.0**	**6.7**	**4.0**	**3.5**	**3.1**
Former Soviet Union	1.3	3.8	6.5	3.5	3.1	—
Eastern Europe	2.6	4.2	7.1	4.9	4.1	—
Developing Countries	**2.9**	**5.0**	**6.3**	**5.5**	**4.8**	**—**
Asia	3.3	5.7	7.0	6.1	5.3	—
China	4.6	7.0	8.5	7.6	6.7	5.2
Other Asia[b]	2.6	4.9	6.1	5.3	4.6	4.2-4.9
Middle East	2.2	4.3	5.7	4.1	4.1	3.2
Africa	2.3	3.9	5.3	3.5	3.6	2.9
Latin America	2.5	4.2	5.5	4.6	4.3	3.2
Total World	**2.0**	**3.2**	**4.3**	**3.1**	**2.9**	**3.1**

[a]North America includes only the United States. Industrialized Asia includes only Japan.
[b]Other Asia includes India and South Korea.

Sources: ***IEO2001*:** Energy Information Administration (EIA), World Energy Projection System (2001). ***IEO2000*:** EIA, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000), Table A1, p. 169. **S&P:** Standard & Poor's Platt's, *World Energy Service: World Outlook 1999* (Lexington, MA, January 1999). **IEA:** International Energy Agency, *World Energy Outlook 2000* (Paris, France, November 2000), p. 352.

In terms of oil consumption, all the forecasts expect similar growth worldwide between 1997 and 2010. Oil demand is projected to increase by between 1.9 percent per year (PIRA) and 2.1 percent per year (S&P and *IEO2001*). All the forecasts expect natural gas use to grow more rapidly than other fuels between 1997 and 2010. *IEO2001* expects slower growth in coal use over the 13-year period than do the other forecasts. The *IEO2001* projection is for 0.8-percent average annual growth, as compared with a range of 1.7 percent per year (IEA) to 2.2 percent per year (PIRA) in the other forecasts.

IEO2001 is more optimistic about the prospects for nuclear electricity generation, projecting average growth of 1.0 percent per year between 1997 and 2010, as compared with the range of 0.6 percent per year (PEL) to 0.8 percent per year (IEA) projected in the other forecasts. This optimism reflects the expectations that nuclear generators in the United States and other parts of the industrialized world and in the EE/FSU will not be retired as quickly as expected in prior outlooks, and that generation from nuclear power will not decline as rapidly or by as much as projected in *IEO2000*.

PEL and *IEO2001* provide world energy consumption projections by fuel for 2015 (Table 9). The two forecasts reflect similar views about oil and renewable energy consumption between 1997 and 2015 but different views about natural gas, coal, and nuclear power. *IEO2001* expects strong growth in natural gas use to result in slow growth in coal consumption, particularly for electric power generation. PEL expects natural gas use to grow more slowly and coal use to grow more rapidly than projected in *IEO2001*. *IEO2001* projects much higher growth in nuclear power use (0.8 percent per year) than does PEL (0.2 percent per year).

IEO2001, IEA, and S&P are the only forecasts that provide projections for 2020 (Table 10). The three forecasts

Table 8. Comparison of World Energy Consumption Growth Rates by Fuel, 1997-2010
(Average Annual Percent Growth)

Fuel	*IEO2001* Low Growth	*IEO2001* Reference	*IEO2001* High Growth	*IEO2000*	S&P	IEA	PIRA	PEL
Oil	1.4	2.1	2.7	1.9	2.1	2.0	1.9	2.0
Natural Gas	2.1	3.1	3.8	3.3	3.2	2.8	3.4	3.0
Coal	0.4	0.8	1.5	1.7	2.1	1.7	2.2	1.8
Nuclear	0.8	1.0	1.5	0.6	—[a]	0.8	0.7	0.6
Renewable/Other	1.5	2.2	2.8	2.2	—[a]	2.5	1.8	1.9
Total	**1.3**	**2.0**	**2.6**	**2.1**	**2.3**	**2.1**	**2.2**	**2.1**
Primary Electricity	1.2	1.7	2.2	1.5	1.7	1.5	1.3	1.4

[a]S&P reports nuclear and hydroelectric power together as "primary electricity."

Sources: ***IEO2001*:** Energy Information Administration (EIA), World Energy Projection System (2001). ***IEO2000*:** EIA, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000), Table A1, p. 169. **S&P:** Standard & Poor's Platt's, *World Energy Service: World Outlook 1999* (Lexington, MA, January 1999), p. 3. **IEA:** International Energy Agency, World Energy Outlook 2000 (Paris, France, November 2000), pp. 364-418. **PIRA:** PIRA Energy Group, Retainer Client Seminar (New York, NY, October 1999), Table II-8. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, February 2000).

Table 9. Comparison of World Energy Consumption Growth Rates by Fuel, 1997-2015
(Average Annual Percent Growth)

Fuel	*IEO2001* Low Growth	*IEO2001* Reference	*IEO2001* High Growth	*IEO2000*	PEL
Oil	1.4	2.2	2.9	2.0	2.0
Natural Gas	2.3	3.1	3.9	3.1	2.8
Coal	0.4	1.0	1.7	1.5	1.6
Nuclear	0.5	0.8	1.3	0.1	0.2
Renewable/Other	1.4	2.1	2.7	1.9	1.9
Total	**1.3**	**2.1**	**2.7**	**2.0**	**2.0**
Primary Electricity	1.0	1.6	2.2	1.2	1.3

Sources: ***IEO2001*:** Energy Information Administration (EIA), World Energy Projection System (2001). ***IEO2000*:** EIA, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000), Table A1, p. 169. **PEL:** Petroleum Economics, Ltd., *Oil and Energy Outlook to 2015* (London, United Kingdom, February 2000).

show similar expectations for growth in oil and natural gas use but different expectations for coal and nuclear power. In the *IEO2001* reference case, coal use is projected to increase by 1.0 percent per year, whereas the IEA and S&P projections are considerably higher, at 2.7 and 3.0 percent per year, respectively. Much of the future coal use in the *IEO2001* projection is offset by a more robust forecast for nuclear power than in either of the other two forecasts. *IEO2001* expects primary electricity use (nuclear power and renewable energy) to increase by 1.4 percent per year, compared with 1.0 percent per year in the IEA and S&P forecasts.

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Table 10. Comparison of World Energy Consumption Growth Rates by Fuel, 1997-2020
(Average Annual Percent Growth)

Fuel	*IEO2001* Low Growth	*IEO2001* Reference	*IEO2001* High Growth	*IEO2000*	S&P	IEA
Oil	1.4	2.2	2.9	1.9	2.1	1.9
Natural Gas	2.3	3.1	3.8	3.2	3.0	2.7
Coal	0.3	1.0	1.8	1.6	2.1	1.7
Nuclear	0.3	0.5	1.1	-0.3	—[a]	0.0
Renewable/Other	1.3	2.0	2.7	1.9	—[a]	2.3
Total	**1.3**	**2.1**	**2.8**	**2.1**	**2.3**	**2.0**
Primary Electricity[a]	0.9	1.4	2.1	1.1	1.0	1.0

[a]S&P reports nuclear and hydroelectric power together as "primary electricity."

Sources: ***IEO2001*:** Energy Information Administration (EIA), World Energy Projection System (2001). ***IEO2000*:** EIA, *International Energy Outlook 2000*, DOE/EIA-0484(2000) (Washington, DC, March 2000), Table A1, p. 169. **S&P:** Standard & Poor's Platt's, *World Energy Service: World Outlook 1999* (Lexington, MA, January 1999), p. 3. **IEA:** International Energy Agency, World Energy Outlook 2000 (Paris, France, November 2000), pp. 364-418.

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